HVI SHORT FIBER MEASUREMENTS

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Abstract

The Cotton Program has evaluated the Zellweger Uster HVI short fiber measurement over the past four classing seasons. Prior to the 2000 classing season, a revision was made to the short fiber algorithm by Zellweger Uster in an attempt to improve measurement repeatability. Results of the revised algorithm were mixed, with some increase in overall within-lab reproducibility and some decrease in between-lab reproducibility. Overall within-lab reproducibility (tolerance of 1.0) was 61% for year 2000 crop samples compared with 58% for 1999 crop samples. Between-lab reproducibility (tolerance of 1.0) dropped to 50% for 2000 from 52% for 1999.

The predicted short fiber measurement, based on HVI length and uniformity index, has been under evaluation since 1998 (Knowlton, 1999). The predicted short fiber evaluation for year 2000 crop samples resulted in within-laboratory reproducibility of 76% (tolerance of 1.0), up from about 75% for the 1998 and 1999 evaluations. Between-laboratory reproducibility for year 2000 crop samples averaged 74%.

An acceptable short fiber content measurement must have greater accuracy than currently available in either of the above methods in order to provide information regarding short fiber normality for a given HVI length and uniformity index. Until this level of short fiber measurement accuracy is achieved, there is no new information provided beyond what is already known in the HVI length and uniformity index measurements. In the current classification system, where two-specimen tests are utilized, the conclusion after four years of evaluation is that the predicted short fiber measurement provides the best estimation of short fiber currently available.

Introduction

Short fiber content is defined as the percentage of fibers in a sample, by weight, less than one half inch in length (Bargeron, 1991). Direct short fiber content measurements can be made with methods such as the Suter-Webb Array and AFIS. Although methods such as these provide useful information, testing speed is slow and the short fiber measurement accuracy is questionable. Another option for obtaining a measurement of short fiber is through the HVI system. All HVI length related measurements such as length and uniformity index are derived from the HVI length fibrogram. Similarly, information exists in the fibrogram to provide an estimate of a cotton's short fiber content. Since many of the short fibers in a sample are too short to extend from the HVI's specimen holding clamp into the optical scanning device, a direct short fiber content measurement is not possible.

A second method, under evaluation since 1998, utilizes a prediction model to derive a short fiber measurement from the HVI measurements of length and uniformity index. Fiber length and short fiber content are strongly related. Uniformity Index also has a strong relationship that is inversely proportional to short fiber content.

Methods

HVI Short Fiber Index

The addition of the Zellweger Uster HVI Short Fiber Index measurement does not require any HVI hardware modifications. Since this measurement is derived from the same fibrogram used in the determination of length and uniformity index measurements, the only change was the addition of the short fiber algorithm to the HVI's operating software.

The first version of the HVI short fiber index measurement was evaluated in 1997. This early version did not use cotton standards as a basis for calibration. The calibration routine relied on hardware settings which were not successful in providing a common level of testing between multiple instruments (Ramey, 1998). In 1998, a short fiber cotton calibration was developed and added to the existing strength, length and uniformity index cotton calibration routine. Short fiber index values were established on an initial set of calibration cottons using an AFIS instrument. Subsequent value establishment on replacement standards was performed by the Quality Assurance Section on HVI's calibrated to the initial set. Results of the 1998 evaluation showed a reduction in level differences in addition to improved reproducibility between HVI systems (Gibson, 1999).

Tables 1 through 4 summarize evaluation results for the 1998, 1999 and 2000 crop year evaluations. Zellweger Uster made a revision in the short fiber index algorithm prior to the 2000 crop year with the objective of improving repeatability. Overall within office reproducibility increased from 58% to 61% comparing year 2000 crop results with the two previous years. However, between office reproducibility has declined since the 1998 crop year evaluation.

Predicted Short Fiber Index

Considerable research has shown the predictability of short fiber content from HVI measurements of length and uniformity index (Zeidman, 1991; Bragg, 1994; Ramey 1998; Rowland, 1999). The concept of predicting short fiber content from the HVI measurements of length and uniformity index was investigated in 1989 (Zeidman, 1991). This work resulted in a first order prediction model known as the "Zeidman equation." More recent work has shown that an improved prediction model can be developed with the help of a second order prediction model (Rowland, 1999). The advantage of the second order model over the first is the ability to provide accurate short fiber predictions over a wider range of fiber lengths.

The Cotton Program began development of a short fiber prediction equation during the evaluations of the HVI short fiber index measurement. Several equation revisions were made as more HVI short fiber index data was collected. The data used for developing the final prediction equation came from 31,000 samples tested two times in 1998 by the Cotton Program's Quality Assurance check lot program. These samples are representative of all the major U.S. cotton growing areas and therefore have a very wide range of fiber lengths and short fiber contents. In addition, the data contained the necessary measurements of HVI length, uniformity index and short fiber index for development of a prediction equation. In order to give the proper weighting to the data, average short fiber indexes were calculated for every combination of length and uniformity index. A total of 269 combinations of length and uniformity index along with the averaged short fiber indexes were computed. Table 5 is a sampling of the combination data used in deriving the short fiber prediction equation. The sample count shows the data distribution for the given length grouping.

The regression analysis of the combination data set resulted in an R^2 of 0.97 and produced the second order equation given below:

$$Z = a + bX + cY + dX^2 + eY^2 + fXY$$

where
Z = Predicted Short Fiber Index
X = HVI Length
Y = Uniformity Index
a = 384.39664 b = -120.3791 c = -6.700362
d = 12.490109 e = 0.0295697 f = 1.0305676

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The predicted short fiber measurement provides the simplest method for obtaining HVI short fiber information. Obtaining short fiber information is simply a matter of plugging length and uniformity index measurements into the equation. Since the short fiber measurement is derived from these well established measurements, additional calibration routines and calibration standards are not required.

Tables 2, 2a, 4 and 4a show that the predicted measurement not only agrees well with the HVI short fiber measurement, but is also more reproducible. In addition, the predicted short fiber measurement does not show near the reduction from within-lab to between-lab reproducibility as the HVI short fiber measurement.

Discussion

When utilizing short fiber measurements, the normality of the short fiber content must be considered. Short fiber content, as currently defined, is confounded with length and uniformity index. For example, using data from Table 5, 10.35% short fiber content is normal for cotton with a 1.07 inch length and 81% uniformity index. However, for cotton with a length of 1.07 inches and 83% uniformity index, a 10.35% short fiber content would be higher than normal.

A second definition of short fiber content could be made relative to the fiber length and uniformity index in addition to the accepted definition of short fiber content that uses an absolute one-half inch length as its reference. A normalized short fiber content would result and could be based on a distribution of all length and uniformity index combinations such as the data from which Table 5 is taken. For instance, take a cotton with length and uniformity index of 1.07 and 81, respectively, and a short fiber content of 11%. Given that a normal normalized short fiber content is 1.0; by dividing 11% by the expected short fiber content (from Table 5) of 10.35%, a normalized short fiber content of 1.06 is obtained. Normalized short fiber contents greater than 1.0 have a higher degree of short fiber than normal. Normalized short fiber contents less than 1.0 have a lower than normal degree of short fiber.

Conclusion

Any new HVI measurement being considered for addition to the classification system must be reproducible and should have a proven utility value. Current measurement precision shows that two classing labs measuring the same piece of cotton, on average, can only expect agreement within a range of two units about half of the time. In addition, 95% of all HVI short fiber index measurements, within general classing office data, fall within a range of only about four to five short fiber content measurement units. Low reproducibility combined with a narrow measurement range do not provide the accuracy necessary for good measurement utilization.

The only way to achieve current HVI short fiber measurement repeatability levels similar to other HVI measurements would be to increase the number of test specimens made on each sample. Unfortunately, this is not possible given the added costs and extra testing time required for such a change in the classification system. Given the current precision available in current classification’s two specimen sample test, four classing seasons of evaluations have lead the Cotton Program to the conclusion that the predicted short fiber measurement offers a more reliable estimation of a cotton’s short fiber content. More importantly, however, is that little if any evidence has yet shown that either short fiber measurement method offers any additional utility value over current HVI length and uniformity index measurements. Future developments and evaluations of short fiber content measurements should consider the necessity of normalization to the measurements of HVI length and uniformity index.

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Table 1. Within Office Evaluation; Sample Counts .

Classing Office	1998	1999	2000
Florence	10,344	7,376	10,255
Macon	8,591	9,794	9,009
Birmingham	3,887	5,192	4,432
Rayville	4,455	6,902	6,644
Dumas	12,548	15,336	13,564
Hayti	3,192	2,113	-----
Memphis	8,219	11,373	14,702
Abilene	2,772	5,959	3,715
Corpus Christi	254	7,963	7,876
Lubbock	12,065	14,912	12,741
Lamesa	2,899	4,957	2,488
Phoenix	2,758	5,239	6,377
Visalia	6,649	10,729	13,114
Totals	78,633	107,845	104,917

Table 2. Within Office Evaluation; Averages and Reproducibilities for HVI Short Fiber Measurement.

	SF Averages			Reproductibility (%)		
Classing Office	**1998**	**1999**	**2000**	**1998**	**1999**	**2000**
Florence	9.9	10.7	11.2	58	60	60
Macon	10.8	11.4	11.3	56	59	59
Birmingham	10.6	11.7	11.3	55	55	59
Rayville	10.1	11.0	11.3	56	55	58
Dumas	9.8	10.3	10.8	59	60	63
Hayti	9.5	9.9	----	60	59	----
Memphis	9.7	10.0	10.9	60	58	63
Abilene	11.0	12.3	12.8	54	51	54
Corpus Christi	10.2	10.6	10.7	56	55	62
Lubbock	10.6	11.6	13.2	57	56	53
Lamesa	10.4	11.7	13.1	56	56	54
Phoenix	10.3	10.9	10.9	55	55	62
Visalia	8.6	9.5	9.6	69	68	72
Totals	10.1	10.8	11.2	58	58	61

Table 2a. Within Office Evaluation; Averages and Reproducibilities for **Predicted** Short Fiber Measurement.

Classing Office	**SF Averages 2000**	**Reproductibility (%) 2000**
Florence	10.7	75.3
Macon	10.8	73.6
Birmingham	11.0	74.2
Rayville	10.9	73.5
Dumas	10.5	76.8
Hayti	----	----
Memphis	10.5	77.4
Abilene	11.9	69.3
Corpus Christi	10.8	77.7
Lubbock	12.2	70.0
Lamesa	12.1	72.3
Phoenix	10.4	76.1
Visalia	9.4	84.6
Totals	10.8	76.0

Table 3. Between Office Evaluation; Sample Counts

Classing Office	**1998**	**1999**	**2000**
Macon	1,194	2,211	2,153
Dumas	435	1,900	751
Memphis	----	----	451
Corpus Christi	----	----	3,196
Lubbock	1,300	2,261	3,220
Visalia	1,750	2,824	2,493
Totals	4,679	9,196	12,264

Table 4. Between Office Evaluation; Averages and Reproducibilities for HVI Short Fiber Measurement.

Classing	**Classing Office Averages**			**Reproducibility(%)**		
Office	**1998**	**1999**	**2000**	**1998**	**1999**	**2000**
Macon	11.4	11.7	11.1	52	46	49
Dumas	10.4	10.4	11.4	51	55	46
Memphis	----	----	11.4	----	----	50
Corpus Christi	----	----	10.8	----	----	57
Lubbock	10.3	11.3	13.1	52	45	44
Visalia	8.4	9.5	9.3	67	60	50
Totals	9.9	10.7	11.2	57	52	50

Table 4a. Between Office Evaluation; Averages and Reproducibilities for **Predicted** Short Fiber Measurement.

Classing Office	**Classing Office SF Averages 2000**	**Reproducibility(%) 2000**
Macon	10.8	71.8
Dumas	10.5	75.6
Memphis	10.6	74.6
Corpus Christi	10.7	75.9
Lubbock	12.2	69.7
Visalia	9.4	80.5
Totals	10.7	73.8

Table 5. Sample of the Distribution of Length and Index Uniformity Combinations with SF.

Length (inches)	**Uniformity Index (%)**	**HVI SFI (%)**	**Sample Count**
1.07	77	14.17	3
1.07	78	13.17	46
1.07	79	12.12	304
1.07	80	11.26	1078
1.07	81	10.35	1926
1.07	82	9.52	1375
1.07	83	8.84	309
1.07	84	8.10	23